

Do we need stacktail betatron cooling?

- Input conditions:
 - ≥ 50 mA/hour
 - 50π mm mr (95% normalized)
 - 2 second cycles
- Output Conditions
 - ≥ 50 mA/hour
 - $\leq 10 \pi$
 - ~ 30 minutes
 - Max stack size ~ 30 mA
- Core Betatron Cooling
 - 3 bands
 - Slotted waveguide pickups and kickers
 - ~ 3.5 GHz total bandwidth
- Lots of stacktail power
 - Extra heating terms
- Low stack sizes
 - Good cooling rates

Mcginnis Model, Summer 03

- Recast standard transverse cooling equation

$$\frac{d\epsilon}{dt} = -\frac{W}{N} [2\text{Re}\{g\} - |g|^2 \left(\frac{1}{n_l} \sum_n \frac{f_0}{\Delta f_n} \right) - |g|^2 U] \epsilon$$

- Form suitable for stacking, where density is changing as function of energy and time

$$\frac{d\epsilon(t, E)}{dt} = -\frac{1}{\tau_c} \left(2\text{Re}\{x\} - |x|^2 \frac{M(E)}{M(E_c)} \right) \epsilon(t, E) + \frac{|x|^2}{\tau_c} \frac{U_0}{M(E_c)}$$

- Integrate over time to follow evolution of 95% point

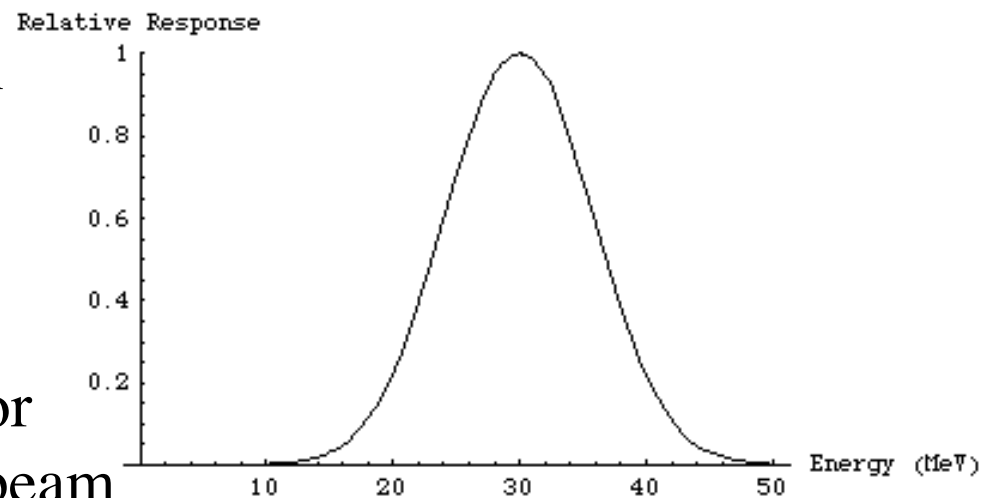
Modelling

- Core systems:
 - optimum gain at handoff from stacktail to core (momentum)
- Stacktail system:
 - 1-6% of optimum gain
 - Power limited
 - 50 W / tube

	Center (GHz)	Width (GHz)
Core B1	4.833	1.167
Core B2	6	1.167
Core B3	7.167	1.167
Stacktail	5	1

Major difference in calculation

- Stacktail ‘gain’ is energy dependent
 - Pickup and kickers are in high dispersion
 - Noise kick is also energy dependent
 - Use model of response for transverse pickups with beam centered in aperture
 - See R. Shafer, Pbar 232



Core Betatron Results

- Dave Summer 03 DoE paper:
 - Core at optimum gain:
 - 2.9π
 - Core at 1.6x optimum gain:
 - 2.1π
- Mathematica calculation:
 - Core at optimum gain
 - 5.2π
 - Core at 1.6x optimum gain:
 - 2.1π

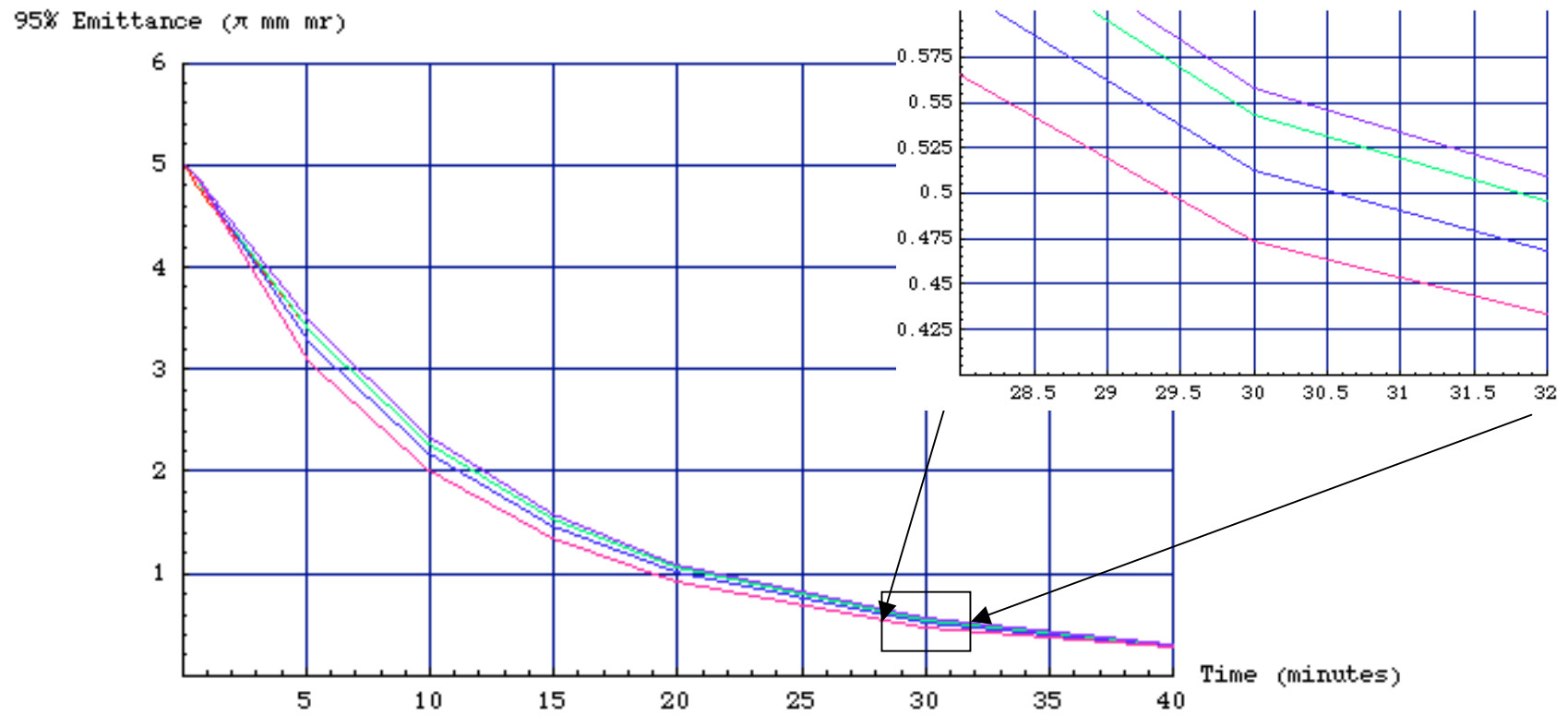
Stacktail optimum gain calculation

- Signal power:
 - Convolute pickup response with density distribution with approximate form for emittance vs energy (based on form with just core betatron cooling)
- Noise power:
 - Effective temperature of 125 K
 - Stacktail momentum system
 - Assumes Liquid Nitrogen cooling of pickups!
- Power limitations:
 - 50 W / TWT
 - 1 - 2 TWT's per 32 kicker loops (historically, run with 1 TWT per 32 loops)

Scenarios

1. Core betatron only, optimum gain
 - Used in other 4 scenarios
2. Stacktail pickup, 15 MeV, 1% optimum gain
 - Proposed location for momentum system
 - Kicker tanks at A20
3. Stacktail pickup, 22.5 MeV, 1% optimum gain
 - Require new pickup tanks at A20, new cryo supply
 - Kicker tanks at A40
4. Stacktail pickup, 30 MeV, 3% optimum gain
 - Require new pickup tanks at A20, new cryo supply
 - Kicker tanks at A40
5. Stacktail pickup, 30 MeV, 6% optimum gain
 - Require new pickup tanks at A20, new cryo supply
 - Kicker tanks at A40

Results



11/19/03

P Derwent

Results

Pickup Position	Fraction of Optimum Gain	95% Emittance after 30 minutes
Core Only		5.2π
15 MeV	1%	5.1π
22.5 MeV	1%	5.1π
30 MeV	3%	4.8π
30 MeV	6%	4.5π

Conclusions

- Addition of stacktail betatron using stacktail momentum pickups
 - Not useful (few% improvement)
- Addition of stacktail betatron using new pickups
 - 15% improvement
 - Significant cost
 - TWTs: ~20 necessary (\$800K?)
 - Cryo plumbing
 - Not worth the investment
- Do not proceed with installation of this system